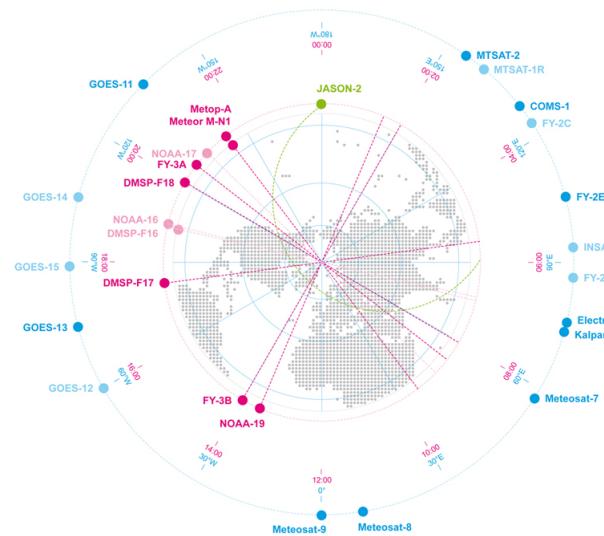


CGMS-47 IOC-WP-01 (Plenary Session **H.2**)
In Response to CGMS-46 Plenary Action 46.12 (HLPP 3.6)



Satellite Data Requirements for UN Decade of Ocean Science for Sustainable Development 2021-2030

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Intergovernmental Oceanographic Commission



Joint Technical Commission on Oceanography
and Marine Meteorology



CGMS

**Coordination Group for
Meteorological Satellites**

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History of JCOMM Ocean Satellite Data Activity (1/2)

- JCOMM-4 Assembly, 28-31 May 2012, Yeosu (Republic of Korea)
 - SFSPA* established Task Team on Satellite Data Requirements (TT-SAT)
 - Annual guidance on satellite oceanography to CGMS (2011-2018)
 - CGMS-46 (2018) Halpern, D., C.-Y. Chung, M. Kachi, Y. Kurihara, T. Kitajima, S. Omori, R. Kumar, S.-S. Picart and H.-M. Zhang. Geostationary Satellite Measurements of Essential Ocean Variables.
 - CGMS-45 (2017) Halpern, D., S. Abdalla, J.-R. Bidlot and K. Ichikawa. Satellite Measurements of Ocean Surface Waves.
 - CGMS-44 (2016) Halpern, D., M. Drinkwater, W. Meier and H. Melling. Satellite Sea Ice Measurements in the Arctic Ocean.
 - CGMS-43 (2015) Halpern, D., J. Font and G. Lagerloef. Aquarius and SMOS Sea Surface Salinity Measurements: A Review of Initial Results.
 - CGMS-42 (2014) Halpern, D., E. Bayler and T. Dickey. Ocean Biology Impacts on Weather Forecasting and El Niño Prediction.
 - CGMS-41 (2013) Halpern, D. and L.-L. Fu. Satellite Global Ocean Surface Topography Measurements: Challenges and Opportunities.
 - CGMS-40 (2012) Halpern, D. Ocean Surface Vector Wind: Research Challenges and Operational Opportunities.
 - CGMS-39 (2011) Halpern, D. Sea Surface Temperature for Numerical Weather Prediction.

➤ JCOMM TT-SAT disbanded itself in 2017

**Coordination Group for
Meteorological Satellites**

* SFSPA = Services and Forecasting Systems Program Area



History of JCOMM Ocean Satellite Data Activity (2/2)

- JCOMM-5 Assembly, 25-29 October 2017, Geneva
 - SFSPA established JCOMM Satellite Data Coordinator with two ToR
 - ❖ Coordinate such activities within JCOMM and act as a JCOMM liaison with WMO CBS ET-SAT and IPET-SUP and with CEOS and CGMS
 - ❖ Report to the chair of the SFSPA Coordination Group
 - May 2018 – WMO appointed David Halpern to be JCOMM Satellite Data Coordinator
- JCOMM Satellite Data Coordinator
 - Establish annual projects
 - ❖ 2019 – Satellite data requirements for UN Decade of Ocean Science for Sustainable Development
 - Jun 2018 – CGMS-47 concurred
 - Jul 2018 – IOC Albert Fischer concurred
 - Sep 2018 – SFSPA CG concurred

Organizational Themes

- UN Sendai Framework for Disaster Risk Reduction (Mar 2015)

- Reduce disaster risk
 - Marine transportation
 - Storm surge forecasting
 - Tsunami forecasting



- UN Agenda 2030 Sustainable Development Goals (Sep 2015)

- Goal 14 – Life below water
 - Coastal ocean eutrophication

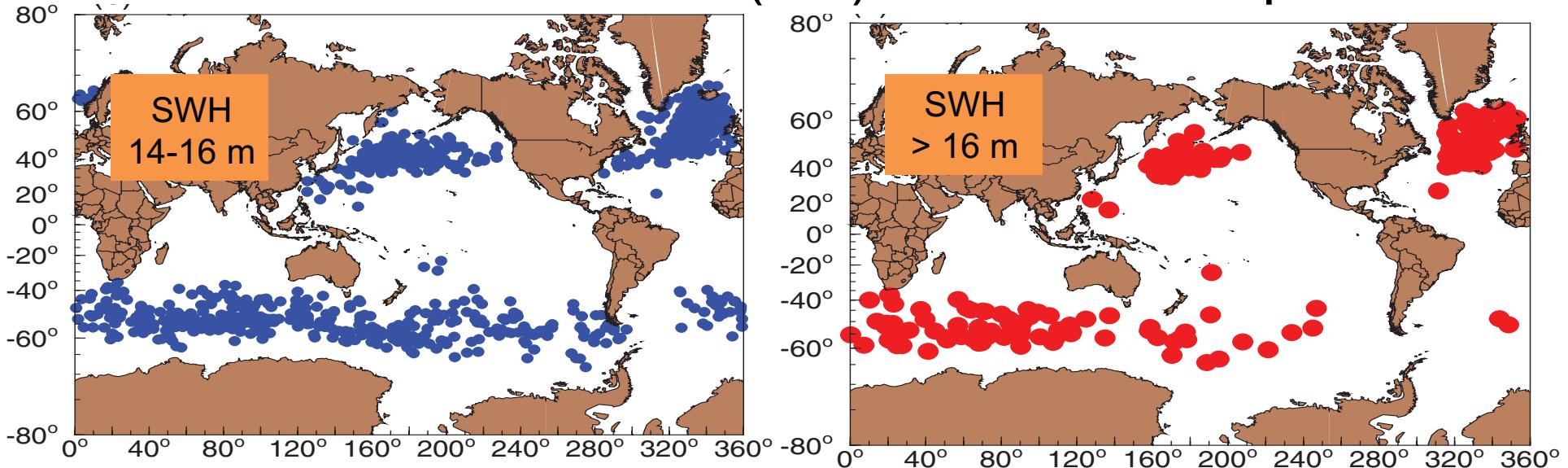


- UNFCCC Paris Agreement (Dec 2015)

- Mitigation and adaptation actions
 - Ship routing forecasting
 - Sea level trend



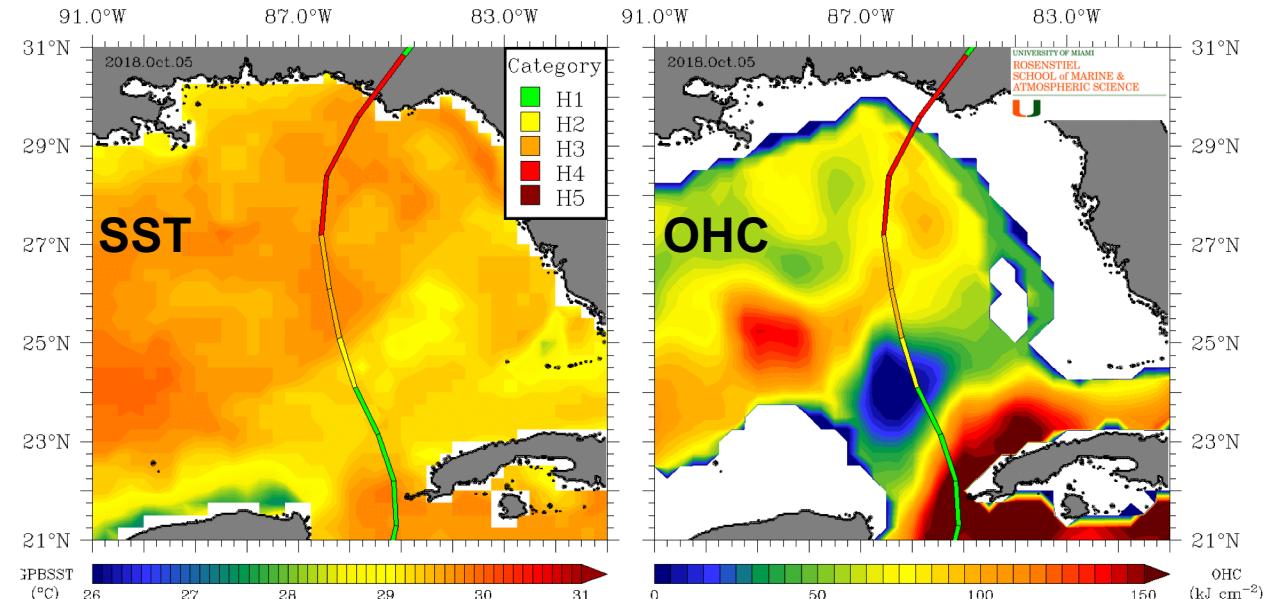
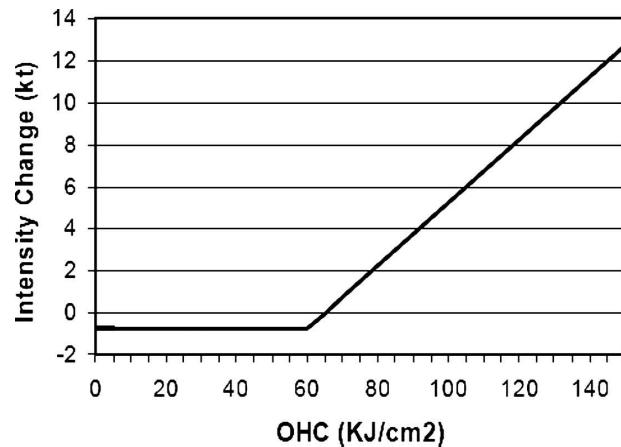
Sendai Framework DRR (1/4): Marine Transportation



- JCOMM project to describe very extreme sea state (VESS)
- VESS = significant wave height (SWH) > 14 m
- SWH = mean trough-to-crest height of the highest third waves = 4 times standard deviation of surface height = 4 times integral of wave spectrum
- VESS climatology 1991-2010 with satellite altimeters (Σ orbits > 5000)
 - could **not** be achieved with in-situ data because ships avoid heavy seas
 - SWH(18-20 m) occurred 17 times; SWH(> 20 m), 3 times; SWH(max) = 20.6 m
 - ERS-1, ERS-2, ENVISAT, GFO, Jason-1, Jason-2, TOPEX
- Heavy seas cause ~30% of major ship problems

Sendai Framework DRR (2/4): Storm Surge Forecast

- $OHC = \int c_p T(z) dz$ from $z=0$ to $z=\text{depth of isotherm}$, e.g., 26°C
- High OHC (thick ocean mixed layer) beneath hurricane = large heat reservoir, which reduces SST cooling from thermocline
- Sparse real-time in-situ data requires satellite ocean surface topography data, combined with climatological-mean depth of specific isotherm



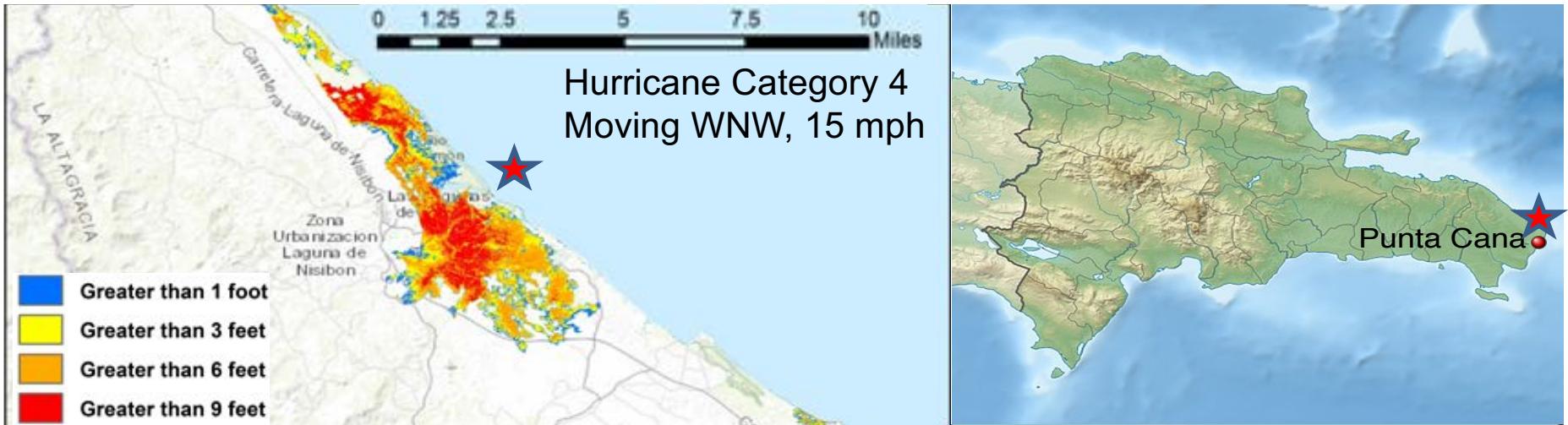
Assimilation of OHC increased wind speed of NOAA National Hurricane Center 72- to 96-h forecasts of Cat 5 hurricanes Emily, Isabel, Ivan, Katrina, Rita and Wilma (2003-2005)

Hurricane Michael 2018

Mainelli et al. (2008)

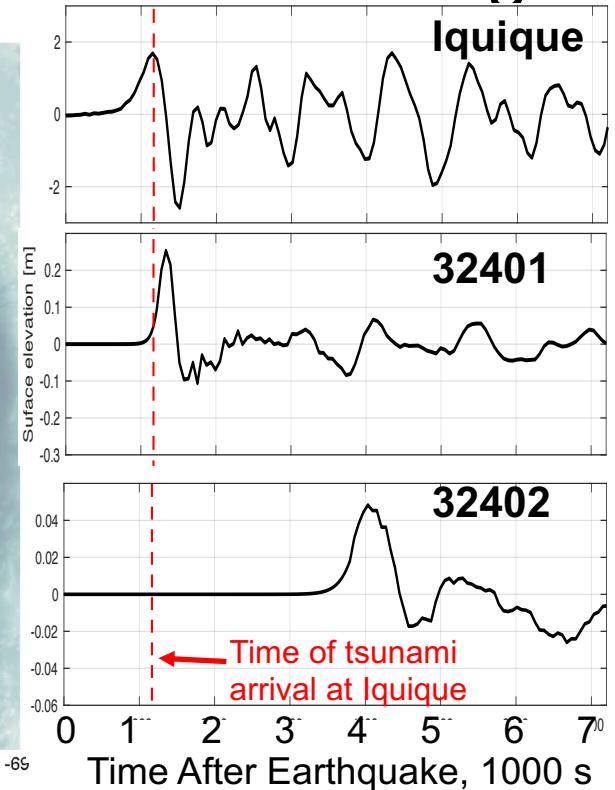
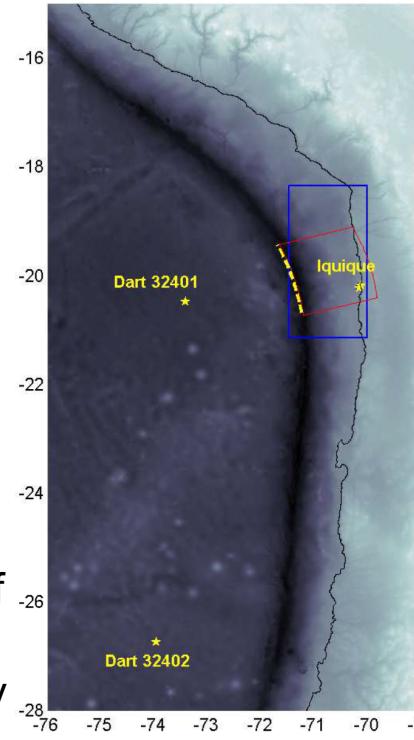
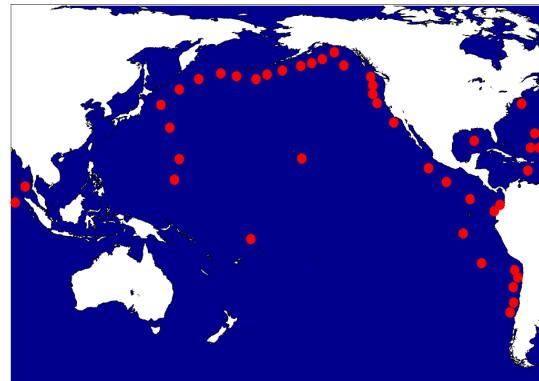
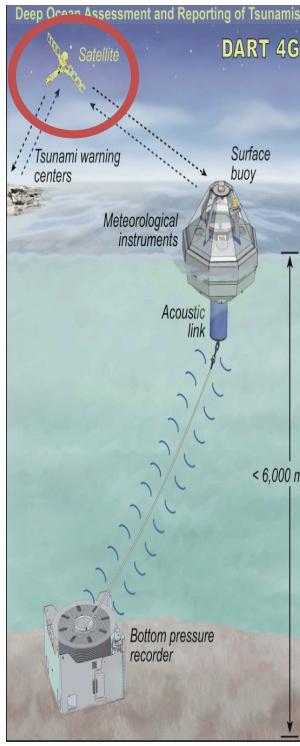
Lynn Shay (pers. comm., November 2018)

Sendai Framework DRR (3/4): Storm Surge Services



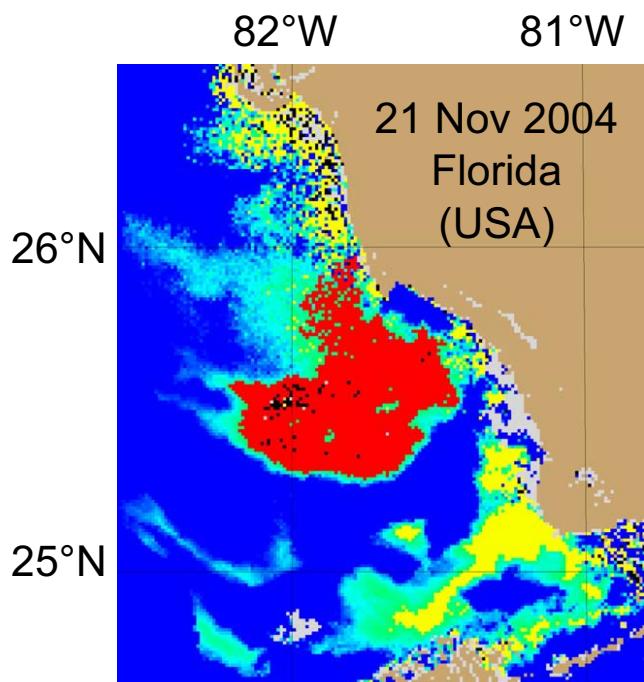
- Coastal Inundation Forecasting Demonstration Project (CIFDP)
 - JCOMM + WMO Commission for Hydrology
 - Hispaniola (Haiti and Dominican Republic) + 3 other regions
 - Forecast providers worked with end-user community
 - Developed easy-to-use early warning system for coastal flooding
 - Computed *a priori* maximum envelopes of coastal flooding
 - ❖ ALOS, ASTER, SRTM, & TANDEM-X measurements of height for DEM
 - ❖ Simulated ~ 16,000 hypothetical storm surges from hurricane category 1-5 moving at different speeds in a variety of directions

Sendai Framework DRR (4/4): Tsunami Forecasting



- t_0 – Earthquake occurs
- $\sim 10 \text{ min}$ – U.S. Geological Survey provides earthquake location and magnitude
- National tsunami warning centers predict tsunami arrival time and magnitude
 - DART data constrain shallow-water model prediction for far-field response
 - DART sites are too far from coastline for useful near-field prediction

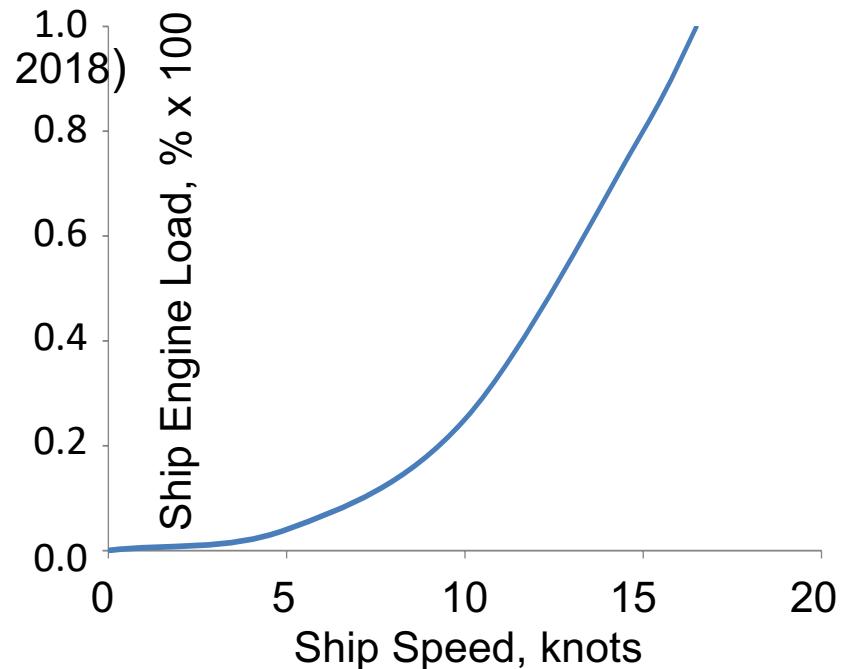
SDG 14.A: Increase knowledge to improve ocean health



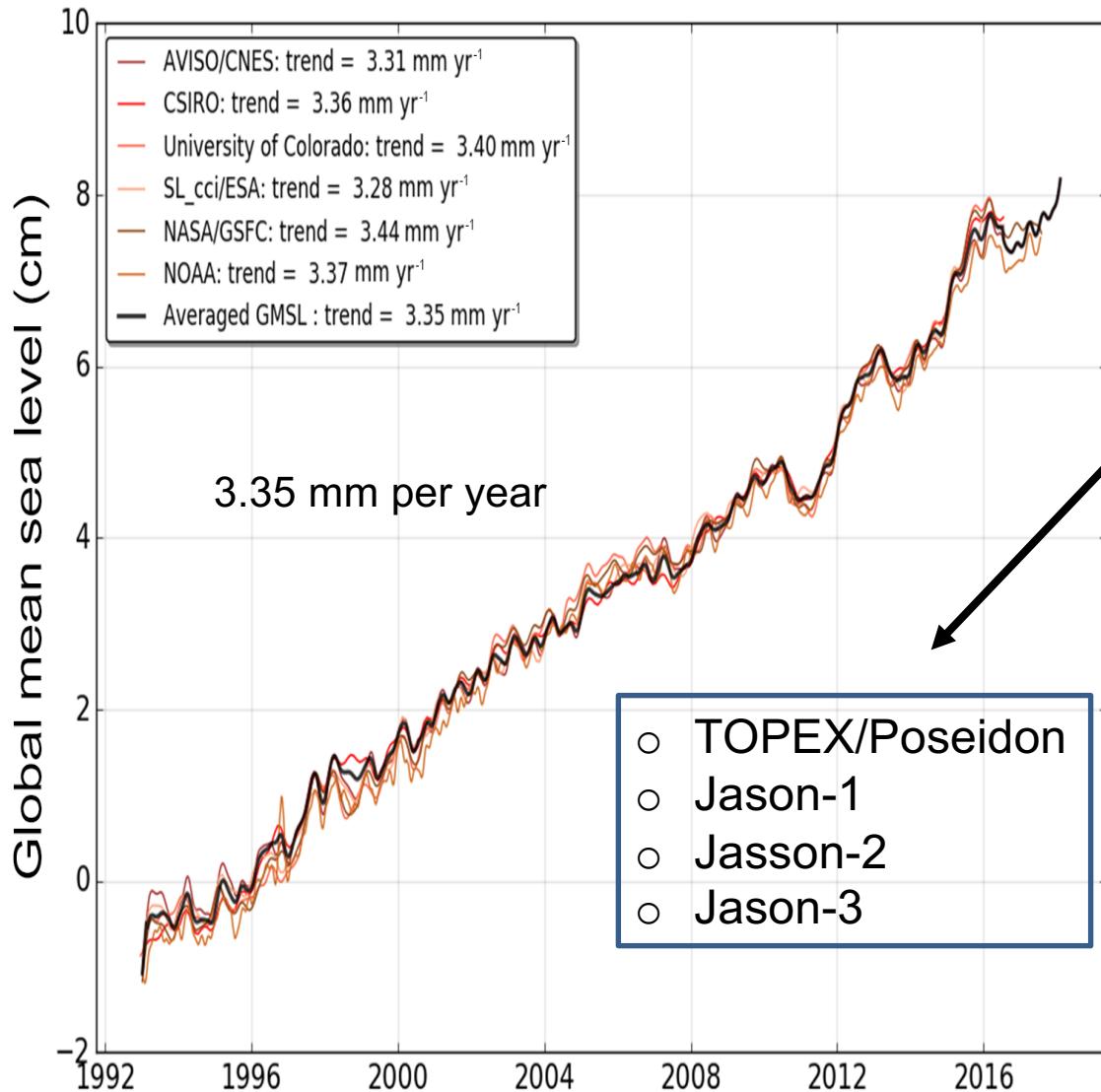
- Locate offshore presence of potential harmful algal bloom (HAB) with ocean color sensors (SeaWiFS, MODIS, MERIS, ...)
- Period of occurrence = August - January
- **Blue** = no Chl-a anomaly
- **Cyan/Green** = Chl-a anomaly $> 0 \text{ mg m}^{-3}$
- **Yellow** = Chl-a anomaly $> 1 \text{ mg m}^{-3}$
- Chl-a anomaly = observed Chl-a at a specific time minus average Chl-a over previous 60 days
- **Red** = HAB prediction
 - Chl-a $> 1 \text{ mg m}^{-3}$
 - In-situ determination of *Karenia brevis* cells
 - Wind-generated transport at the coast
 - Upwelling brings *K. brevis* to surface
 - Downwelling brings *K. brevis* to coast
 - Patch $> 30 \text{ km}^2$, not coast-wide
- Predictive skill
 - 65% - 85%
- Coastal respiratory irritation forecast
 - HAB & surface wind

Paris Agreement (1/2): Ship Routing Forecasting

- Optimal strategy (Arslan et al., 2015)
 - Wind, wave and current forecasts
 - Reduce voyage costs (BAMS 1982)
 - 2-4% fuel & GHG reduction (Motorship, 2018)
 - Ship motion performance
 - Maximize safety
 - Minimize fuel consumption
 - 50-60% of ship operating cost
 - Minimize GHG emissions (IMO 2018)
 - Shipping - 3% of global emissions
 - Tripling of shipping expected by 2050
 - Maximize profits
 - Maximize certainty of arrival time
 - Port berth, loading, unloading
- Dynamic routing strategy (Andersson and Ivehammar, 2016)
 - Ship alters route based on shared information on movements of other ships



Paris Agreement (2/2): Global Mean Sea Level Trend



- Satellite observing systems
 - Reference missions provide the most accurate long-term stability at global and regional scales and are all on the same T/P ground track
 - Additional mission data poleward of 66° and increased resolution
 - ERS-1, ERS-2, Envisat, Sentinel-3A, Geosat Follow-on, SARAL/AltiKa

Key issues of relevance to CGMS

- UN Decade of Ocean Science for Sustainable Development
 - Operational meteorological forecasts (e.g., storm surge forecast and ship routing forecast)
 - Non-operational meteorological forecasts (e.g., tsunami forecast and long-term sea level)
 - Develop potential opportunities for additional observations, e.g., in situ ocean measurements from tsunami watch infrastructure and toxic marine aerosols from HAB infrastructure

To be considered by CGMS



- Establish joint CGMS-IOC coordination mechanism to mutually enhance CGMS weather-and-climate activities with activities of the UN Decade for Ocean Science for Sustainable Development
 - Receive annual briefing on the UN Decade of Ocean Science for Sustainable Development
 - Sustain satellite and in situ system of ocean observing systems
 - Utilize geostationary meteorological satellites for ocean observations
 - Enhance data acquisition for special observing periods
 - Add CGMS-relevant ocean measurements to tsunami watch infrastructure
 - Add HAB toxic aerosols to coastal air pollution forecasts

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CGMS-48 IOC-WP-01 (2020)

- Annual guidance on satellite data requirements for improved coastal ocean prediction and services
 - Contributions to UN Decade of Ocean Science for Sustainable Development
 - Challenges and opportunities of utilizing satellite data to enhance coastal ocean science and services